Cross-Sectional Association Between Serum Vitamin D Concentration and Walking Speed Measured at Usual and Fast Pace Among Older Women: The EPIDOS Study

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Abstract

The purpose of this study was to determine whether there was an association between serum 25-hydroxyvitamin D [25(OH)D] concentration and walking speed measured at usual and fast pace among older women. Usual- and fast-pace walking speeds and 25(OH)D concentrations were assessed in 739 randomized older women (mean age 80.2 ± 3.5 years) from the EPIDOS study. The following 25(OH)D thresholds were used: 10, 20, and 30 ng/mL. Walking speed was dichotomized on being in the worst quintile or not. Age, body mass index, number of chronic diseases, physical activity, quadriceps strength, cognition, use of psychoactive drugs, and serum parathyroid hormone were used as potential confounders. The results show that 90% of subjects had 25(OH)D insufficiency. Only fast-pace walking speed was significantly different between groups ($p = .021$) and decreased from normal serum 25(OH)D concentrations to severe insufficiency (trend $p = .007$). Serum 25(OH)D concentration was associated with walking speed at both usual and fast pace in the unadjusted linear regression ($\beta = 0.16$, $p = .027$ and $\beta = 0.23$, $p = .009$, respectively). This association remained significant only for fast-pace walking after adjustment (adjusted $\beta = 0.18$, $p = .033$) and was strengthened from a lower 25(OH)D value compared with usual pace [25(OH)D = 27.15 ng/mL for fast pace and 38.65 ng/mL for usual

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Disclosures

CA had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. CA and OB were responsible for the study concept and design. A-MS was responsible for data acquisition. CA, OB, MM-O, A-MS, BF, and FRH were responsible for data analysis and interpretation. CA, OB, and A-MS were responsible for drafting the manuscript. MM-O, GB, FRH, and BF were responsible for critical revision of the manuscript for important intellectual content. Funding was obtained by A-MS. Statistical expertise was provided by FRH. Administrative, technical, and/or material support was provided by A-MS. Study supervision was provided by OB and A-MS.

The sponsor had no role in the design and conduct of the study; in the collection, management, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript. All the authors state that they have no conflicts of interest.

pace). Lastly, logistic regression showed a stronger association of serum 25(OH)D insufficiency with fast-pace walking speed whatever the 25(OH)D thresholds used [30 to 20 ng/mL: adjusted odds ratio (adjOR) = 6.01, $p = .003$; 20 to 10 ng/mL: adjOR = 4.10, $p = .014$; <10 ng/mL: adjOR = 6.95, $p = .001$] compared with usual pace (30 to 20 ng/mL: adjOR = 3.79, $p = .022$; 20 to 10 ng/mL: adjOR = 3.76, $p = .016$; <10 ng/mL: adjOR = 5.44, $p = .003$). The findings show a stronger positive association between 25(OH)D concentrations and fast-pace walking speed that is a more sensitive marker of neuromuscular functioning compared with usual-pace walking.

Keywords

VITAMIN D; WALKING SPEED; FAST PACE; MOTOR COORDINATION; AGING

Introduction

Vitamin D insufficiency is common among older adults.^(1,2) Yet its prevalence remains underestimated because the recommended optimal limit value of serum 25-hydroxyvitamin D [25(OH)D] concentration is being adjusted upward, with a cutoff value around 20 or even up to 30 ng/mL.^(1–3) Indeed, there is increasing evidence that when accounting not for skeletal health but the salutary effects of vitamin D on nonskeletal organs, the optimal health-promoting concentration of 25(OH)D is around 30 ng/mL.^(1–11) In particular, adverse neuromuscular events such as muscle weakness, balance impairment, and reduced nerve conduction have been described for serum 25(OH)D concentrations below 30 ng/mL.^(3–11)

Walking speed is a simple, objective performance-based measure of lower limb neuromuscular function that not only allows detection of subtle impairments and preclinical diseases but also is a sensitive marker of functional capacity in older adults.^(10–16) For instance, Suzuki and colleagues recently demonstrated that walking speed in older adults was positively correlated with physical performance tests such as handgrip strength or stork standing time.⁽¹⁶⁾ Furthermore, these authors also found a significant positive association between walking speed at a usual pace and serum 25(OH)D concentrations.⁽¹⁶⁾

Compared with muscle strength or balance performance,^(5–7) fewer attempts have been made to explore the association between low chronic serum 25(OH)D concentrations and walking speed.^(10,16–22) A better understanding of this association is important to further develop interventional clinical studies to assess the effect of vitamin D supplementation on mobility and gait performance and related adverse health consequences. Previous studies showed conflicting results because some of them found a significant positive association, ^(10,16–20) whereas others did not.^(21,22) These differences may be related, in part, to the type of walking speed measured. Compared with usual-pace walking, fast-pace walking requires greater functional reserve and thus provides more information about neuromuscular function.^(15,23) We therefore suggest that fast-pace walking speed compared with usual-pace speed is a sensitive way to assess the effects of low serum 25(OH)D concentrations on walking speed. Mixed results also may be explained by the absence or insufficient control of potential confounders such as age, body mass index (BMI), quadriceps strength, cognitive functioning, physical activity, number of chronic diseases, use of psychoactive drugs, and

concentrations of serum intact parathyroid hormone (iPTH).^(3–11) Lastly, studies used different cutoff values for low serum 25(OH)D concentrations ranging from 10 to 30 ng/mL, which also may explain the divergent results.^(1–3) Thus, to better understand the association of vitamin D with walking speed, every previously used 25(OH)D threshold must be analyzed: 10, 20, and 30 ng/mL.^(1–3,11)

Based on current evidence,⁽⁵⁾ the aim of this study was to determine whether an association of low serum 25(OH)D concentrations (i.e., severe insufficiency <10 ng/mL, moderate insufficiency = between 10 and 20 ng/mL, and mild insufficiency = between 20 and 30 ng/mL) with lower walking speed, either at a usual or fast pace, could be established in older adults. For this purpose, data from the Epidémiologie de l'Ostéoporose (EPIDOS) study was used.

Materials and Methods

Participants

We studied a randomized sample of 739 subjects included in the EPIDOS study, which is a community-dwelling observational prospective cohort study designed to evaluate the risk factors for hip fracture among more than 7500 healthy older women aged 75 years and older. The sampling and data-collection procedures have been described elsewhere in detail.^(7,24) In brief, from 1992 to 1994, 7598 subjects chosen from electoral lists were recruited in five French cities (Amiens, Lyon, Montpellier, Paris, and Toulouse) after having given their written informed consent. Exclusion criteria were the inability to walk independently, a history of hip fracture or bilateral hip replacement, and an inability to understand or answer the study questionnaires. From 7598 women, full clinical data at baseline assessment were available for 6846 women. All included study participants had at the same time a blood test and a full medical examination by trained nurses that consisted of structured questionnaires, information about chronic diseases, and a clinical examination. Sera were stored at -100°C until analyses were performed. A randomized sample of 752 women then was drawn. This choice of 752 women was based on our budgetarian's capacity to perform the laboratory measure of serum 25(OH)D concentration. The randomization process was based on the use of a random-number table that generated in an unpredictable, haphazard sequence of number corresponding to the number of subjects included in the study. From this randomized subset of 752 women, all data were available for 739 women.

The study was conducted in accordance with the ethical standards set forth in the Helsinki Declaration (1983). The project was approved by the local ethics committee of each research center.

Walking speed assessment

Subjects were instructed to stand still with their toes just touching a starting line. On the evaluator's command of "Go," participants had to walk over a 6-m walkway and to continue walking 2 m past the finish line.

Two walking conditions were measured successively in non-randomized order: walking at a self-selected usual pace and walking as fast as possible without running. Before each timed

walk, a trained evaluator gave standardized verbal task instructions to the participants. The ambulation time for each walk was measured with a stopwatch with accuracy in centiseconds. Timing was started with the first heel strike after the starting line and stopped with the first heel strike after the finish line. The evaluator walked alongside the participant for the length of both walks. Times to walk 6 m at both usual and fast pace were converted into measurements of walking speed as centimeters per second by dividing the walkway distance of 600 cm by ambulation time in seconds.

Serum measures

Fasting early-morning venous blood was collected from resting subjects for the measurement of serum 25(OH)D and iPTH. Sera were stored at -100°C until analyses were performed. Serum concentrations of 25(OH)D were measured by radioimmunoassay (Incstar Corp., Stillwater, MN, USA). With this method, there is no lipid interference, which is often observed in other non-chromatographic assays of 25(OH)D. The intra- and interassay precisions were 5.2% and 11.3%, respectively (range 30 to 125 nmol/L in normal adults aged 20 to 60 years). iPTH concentrations were measured by an immunochemoluminometric assay (Magic Lite, Ciba Corning Diagnostic, Medfield, MA, USA; normal range 11 to 55 pg/mL for adults 20 to 60 years of age). The intra- and interassay precisions were 5.2% to 6.8% and 5.0% to 5.5%, respectively. All 25(OH)D and iPTH measurements were performed at Lyon University Hospital.

Clinical covariables

Age, BMI, quadriceps strength, cognitive functioning assessed with Pfeiffer's Short Portable Mental Status Questionnaire (SPMSQ) score,^(25,26) number of chronic diseases, use of psychoactive drugs (including benzodiazepines, antidepressants, or neuroleptics), and regular practice of physical activities were included in this data analysis as potential clinical confounding factors. These covariables were obtained from physical examination and from a health status questionnaire (for detection of hypertension, diabetes, dyslipidemia, coronary artery disease, chronic obstructive pulmonary disease, peripheral vascular disease, cancer, stroke, Parkinson disease, and depression). Maximal isometric voluntary contraction strength of the quadriceps muscle of the dominant side was measured using a strain-gauge system attached to a chair on which subjects were seated with both hips and knees flexed at a 90-degree angle. The leg to be tested was fixed to the lever arm on an analog strain gauge to measure strength. The women were instructed to push against the dynamometers as hard as they could, and the maximal peak pressure expressed in newtons per square meter was recorded.⁽⁷⁾ Regular participation in a physical activity was reported with a self-reported structured questionnaire. The type, frequency, and duration of recreational physical activities were recorded. Participation was considered regular if subjects had practiced at least one recreational physical activity for at least 1 hour per week for at least the past month. BMI was calculated as weight (kg) divided by height² (m²).

Statistical analysis

The subjects' characteristics were summarized using means and standard deviations or frequencies and percentages as appropriate. The normality of the parameters' distribution was verified with skewness and kurtosis tests before and after applying usual

transformations to normalize non-Gaussian variables. For the current analysis, the following cutoff points were used: severe 25(OH)D insufficiency <10 ng/mL, moderate 25(OH)D insufficiency = between 10 and 20 ng/mL, mild 25(OH)D insufficiency = between 20 and 30 ng/mL, and normal concentrations > 30 ng/mL.^(1–3,11) In addition, categorization of walking speeds at both a usual and a fast pace was based on being in the worst quintile or not. Comparisons between subject groups were performed using the independent-samples *t* test, the chi-square test, the Kruskal-Wallis test with Bonferonni correction for multiple-group comparison, or the Cusick test as appropriate. Uni- and multiple linear regression analyses were performed to specify the associations between walking speeds at both usual and fast pace (dependent variable) and serum 25(OH)D concentration (independent variable) adjusted on the subjects' baseline characteristics. To evaluate the dose-response relationship between walking speed and 25(OH)D concentration more closely and to assess possible thresholds, we applied weighted piecewise regression with the constraints that the slope to the left of the breakpoint be zero.⁽²⁷⁾ Weighting was done according to the number of observations in every 5-unit interval of serum 25(OH)D concentration. Lastly, simple and multiple logistic regressions were used to examine the association between the four levels of serum 25(OH)D concentration mentioned earlier (ie, lower than 10 ng/mL, 10 to 20 ng/mL, 20 to 30 ng/mL, and 30 ng/mL or more) and being in the worst quintile of walking speed while taking the subjects' baseline characteristics into account. Different models were performed for usual- and fast-pace walking tests. Values of $p < .05$ were considered statistically significant. Statistical analyses were performed with the use of STATA software (Version 11.0; Stat Corp, College Station, TX, USA).

Results

The subjects in this study were younger than the other participants of the EPIDOS cohort ($p = .012$), had fewer chronic diseases ($p < .001$) and a higher SPMSQ score ($p < .001$), and practiced physical activities more often ($p = .004$) (Table 1). There were no significant differences for the other clinical characteristics, particularly with regard to walking speed.

Ninety percent of selected women had a serum 25(OH)D concentration below 30 ng/mL, 18% between 20 and 30 ng/mL, 55% between 10 and 20 ng/mL, and 17% below 10 ng/mL. Serum 25(OH)D concentration was not associated with quadriceps strength in this studied sample [unadjusted $\beta = 0.03$, 95% confidence interval (CI) -0.32 to 0.38 , with $p = .09$].

As indicated in Table 2, only walking speed measured at a fast pace was significantly different while comparing the four groups of women together [overall $p = .021$, and $p < .001$ for the comparison between severe 25(OH)D insufficiency (ie, <10 ng/mL) and normal 25(OH)D concentration (ie, >30 ng/mL)]. In addition, only fast-pace walking speed decreased significantly from normal serum 25(OH)D concentrations to severe insufficiency (for trend $p = .007$).

Table 3 shows the linear regression analysis results. While a significant association was reported in the univariate analysis between serum 25(OH)D concentrations and measured walking speed at a usual pace, this association was not significant after adjustment for potential confounders (crude $\beta = 0.16$, with $p = .027$, and adjusted $\beta = 0.10$, with $p = .130$).

Conversely, the association between serum 25(OH)D concentration and walking speed measured at a fast pace was significant without (crude $\beta = 0.23$, with $p = .009$) and with adjustment for potential confounders (adjusted $\beta = 0.18$, with $p = .033$; Table 3). In addition, slow walking speeds measured at both a usual and a fast pace were significantly associated with older age (adjusted $\beta = -1.15$, with $p < .001$, and adjusted $\beta = -1.66$, with $p < .001$, respectively), increased BMI (adjusted $\beta = -1.31$, with $p < .001$, and adjusted $\beta = -1.78$, with $p < .001$, respectively), and the use of psychoactive drugs (adjusted $\beta = -7.01$, with $p < .001$, and adjusted $\beta = -5.34$, with $p = .003$, respectively). Conversely, a high quadriceps strength (adjusted $\beta = 0.09$, with $p < .001$, and adjusted $\beta = 0.12$, with $p < .001$, respectively), the regular practice of physical activity (adjusted $\beta = 4.49$, with $p < .001$, and adjusted $\beta = 6.28$, with $p < .001$, respectively), and a high cognitive functioning (adjusted $\beta = 3.12$, with $p < .001$, and adjusted $\beta = 2.72$, with $p < .001$, respectively) were significantly associated with high walking speeds at both usual and fast pace (Table 3). No significant association between serum iPTH and walking speed was found (adjusted $\beta = 0.01$, with $p = .691$, for usual pace and adjusted $\beta = 0.01$, with $p = .925$, for fast pace).

The association between serum 25(OH)D concentration and walking speed is illustrated in Fig. 1. Figures 1A and 1B show the unadjusted mean walking speed at a usual and a fast pace, respectively, in steps of 5 ng/mL of serum 25(OH)D. Figures 1C and 1D show the mean walking speeds adjusted for age, BMI, number of chronic diseases, quadriceps strength, regular physical activity, cognitive functioning, use of psychoactive drugs, and serum iPTH concentration. The breakpoint above which the strength of the association between walking speed and serum 25(OH)D increased was calculated to be 38.65 ng/mL for usual-pace and 27.15 ng/mL for fast-pace walking.

Lastly, the findings from the logistic regression model are shown in Table 4. Multivariate logistic regression showed that low serum 25(OH)D concentrations were significantly associated with low walking speed measured at a usual pace [adjusted odds ratio (adjOR) = 3.79, with $p = .022$, for mild 25(OH)D insufficiency; adjOR = 3.76, with $p = .016$, for moderate 25(OH)D insufficiency; and adjOR = 5.44, with $p = .003$, for severe 25(OH)D insufficiency]. This association with low 25(OH)D concentration was even more close while considering low walking speed measured at a fast pace (adjOR = 6.01, with $p = .003$, for mild insufficiency; adjOR = 4.10, with $p = .014$, for moderate insufficiency; and adjOR = 6.95, with $p = .001$, for severe insufficiency).

Discussion

The findings showed that low serum 25(OH)D concentrations were associated with low walking speeds at a usual pace as well as at a fast pace. After adjustment, the linear association remained significant only for fast-pace walking speed. Similarly, the adjusted logistic regression showed a stronger association of 25(OH)D insufficiency with low walking speed in the fast-pace condition compared with usual-pace. This association was strengthened from a lower cutoff point of 25(OH)D at fast pace compared with the usual pace [25(OH)D = 27.15 ng/mL and 25(OH)D = 38.65 ng/mL, respectively], which highlights the sensitivity and accuracy of the fast-pace walking speed assessment while exploring adverse effects of serum 25(OH)D insufficiency.

Few data are available on the association between serum 25(OH)D concentrations and walking speed.^(10,16–22) It has been shown that ambulation time over an 8-ft walkway correlated with higher serum 25(OH)D concentrations.^(10,18) Gerdhem and colleagues⁽¹⁹⁾ also have reported a positive significant linear correlation with usual walking speed in a cohort of 986 elderly women. However, this result was less reliable than previous studies because no adjustments for confounders were made. Additionally, Kwon and colleagues⁽¹⁸⁾ showed that men with concomitantly low serum albumin and 25(OH)D concentrations had a low timed up and go score, even after adjusting for age and BMI. Finally, Suzuki and colleagues⁽¹⁶⁾ recently highlighted a positive significant linear association with walking speed at a usual pace for either men or women in a larger cohort of 2957 Japanese subjects aged 65 years and older. It has to be stated that two other observational studies^(21,22) found no significant association between serum vitamin D concentrations and usual walking speed. Clinical trials were in line with these results. Verhaar and colleagues⁽²⁰⁾ showed a significant increase in walking distance after 6 months of vitamin D supplementation among vitamin D-deficient women [serum 25(OH)D <8 ng/mL] aged 70 years and older. However, the achievements in the timed up and go test and the 2-minute walk test at a usual pace did not improve in the α -calcidol group compared with the no-substitution group after 6 months.

Differences between studies may result in part from the absence or insufficient control of potential confounders. As an example, our results highlighted a significant positive linear association between serum 25(OH)D level and walking speed at a usual pace, but this relationship was no longer significant when the effects of potential serum and clinical confounders were taken into account.

Second, previous studies used different cutoff values for abnormal serum 25(OH)D concentrations ranging from 10 to 30 ng/mL,^(10,16–22) which also may explain the divergences. From a historical point of view, normal vitamin D concentrations have been defined by the avoidance of adverse health consequences. For example, it has been long recognized that there is neither rickets nor osteomalacia for serum 25(OH)D concentrations above 10 ng/mL^(1–3,28) and no secondary hyperparathyroidism above 20 ng/mL.⁽²⁹⁾ More recently, Bischoff-Ferrari and colleagues elegantly demonstrated that to avoid nonskeletal outcomes of public health significance, the most advantageous serum 25(OH)D concentrations began at 30 ng/mL, and the best were between 36 and 40 ng/mL.⁽³⁾ These observations were consistent with a roundtable conference that stated in 2006 that the reference value for 25(OH)D should be somewhere between 20 and 40 ng/mL, with a clear tendency toward a target of 30 ng/mL.⁽²⁾ Our results confirmed that the nonskeletal implications of vitamin D (ie, on fast-pace walking speed in our study) increase from values around 30 ng/mL (Fig. 1).

Third, the most likely explanation for previous divergent results is the nature of the walking test, as shown by Fitzpatrick and colleagues,⁽²³⁾ who reported that the usual-pace walk test seems to detect fewer differences in functional reserve than the fast-pace test. Our results were in concordance with this previous result.

To the best of our knowledge, our findings are the first evidence of a positive association between serum 25(OH)D concentration and fast-pace walking speed specifically. This strong

positive association may be explained by the combined action of vitamin D on muscles and nerves.^(5–10,30) Even if the association of vitamin D with muscular strength remains controversial^{5,7}—which was confirmed by the lack of significant linear association between serum 25(OH)D and quadriceps strength in our study—its action on muscle contraction speed and muscle power seems likely.^(5,30) It has indeed been shown that serum vitamin D concentrations influence muscular phenotypic determinism because fast-twitch muscle fiber atrophy was identified in adults with vitamin D deficiency.⁽³⁰⁾ These muscles, which contain relatively more slow type I than fast type II muscle fibers, had slower and less powerful muscular contractions, leading to a slower walking speed, especially at a fast pace.⁽³¹⁾ Additionally, vitamin D is a neurosteroid hormone whose insufficiency may cause disturbances in the peripheral nervous system, such as reduced nerve conduction speed, but also in the central nervous system.^(8,9,30,31) For example, vitamin D status has been associated with cognitive function such as attention, which is involved in gait control in older adults.^(32–36) Fast-pace walking is precisely considered as a more attention-demanding task than usual-pace walking,^(23,36) which could explain in part the close positive association shown in our study.

Our results also confirmed that slow walking speeds measured at both usual and fast pace were significantly associated with older age, increased BMI, and the use of psychoactive drugs, whereas high quadriceps strength, regular physical activity, and high cognitive functioning were significantly associated with high walking speeds at both usual and fast pace (Table 3). It is well established that these elements are determinants of walking speed.^(37,38) These results therefore are consensual, which is an argument for the consistency of our study and confirms the relevance of the association with vitamin D.

Conversely, we found no linear association of serum iPTH concentration with walking speeds at both usual and fast pace, either with or without adjustment for potential confounders (Table 3). Serum 25(OH)D and iPTH concentrations are known to be negatively correlated. Thus it is difficult to distinguish any separate effects on muscle function. Stein and colleagues⁽³⁹⁾ have suggested that the muscle effect of 25(OH)D insufficiency could be due to iPTH and not to a direct action of vitamin D on muscle. This relationship between serum iPTH concentrations and muscle has been known for a long time in patients with primary hyperparathyroidism, whose clinical features include muscle weakness⁽⁴⁰⁾ that was reversed after parathyroidectomy.⁽⁴¹⁾ In addition, iPTH already has been associated with usual walking speed in unadjusted models.^(17,19) However, the specific roles of vitamin D and iPTH on muscle and locomotion have not yet been fully elucidated. In our study, the existence of an association between 25(OH)D and walking speed, even after adjustment for iPTH effect, sustains the notion of a direct neuromuscular action of vitamin D, especially because iPTH was not associated with walking speed even in the unadjusted linear regression model.

The prevalence of low serum 25(OH)D concentrations in our subjects was high at 90%, much higher than the prevalence in community-dwelling older adults by approximately 50%.^(1,2) This discrepancy may be related to the choice of cutoff value used to define normal serum 25(OH)D status because previously, cutoffs ranged around 10 ng/mL.⁽¹⁾ Furthermore, the number of chronic diseases in the women studied also may explain the difference in

prevalence. Indeed, it has been shown that chronic diseases may affect vitamin D metabolism in older adults⁽⁴⁾ and thus should be taken into account while evaluating insufficiency. Nevertheless, it is well recognized that the prevalence of vitamin D insufficiency is frequently underestimated^(1,2) and, as a consequence, might be higher than previously reported in community-dwelling older adults.

Our study has some limitations. First, the study cohort was restricted to women and included relatively healthy, vigorous subjects. Therefore, the sample studied may not be representative of community-dwelling older adults. Moreover, the study participants may be more likely motivated by a greater interest in personal health issues than the general population of older adults in independent senior living facilities. Second, limitations of this study include the use of a cross-sectional design, which may limit exploration of the relationship between serum 25(OH)D concentrations and walking speeds and does not allow any causal inference compared with a prospective cohort design. Third, although we were able to control for many characteristics likely to modify this relationship, residual potential confounders still may be present. Fourth, it should be noted that each walk test in the EPIDOS study started at a standstill, which potentially may result in a lack of acceleration opportunities along the 6-m walkway. An additional limitation was the absence of randomized order of the two walk tests to eliminate a learning effect in completion of the second course (ie, the fast-pace walk test).

In conclusion, our study sheds new light on the association between serum 25(OH)D concentrations and walking speeds in older adults. We showed that serum 25(OH)D concentrations were associated with walking speeds, in particular with fast-pace walking, which is a sensitive measure of lower limb neuromuscular functioning. This result adds a new orientation of research into furthering the understanding of how vitamin D affects motor coordination and locomotion. Furthermore, it suggests that the correction of 25(OH)D insufficiency with vitamin D supplementation may improve walking speed in older adults.

Acknowledgments

The EPIDOS study participants included coordinators G Breart, P Dargent-Molina, PJ Meunier, AM Schott, D Hans, and PD Delmas and principal investigators C Baudoin and JL Sebert (Amiens), MC Chapuy and AM Schott (Lyon), F Favier and C Marcelli (Montpellier), CJ Menkes, C Cormier, and E Hausherr (Paris), and H Grandjean and C Ribot (Toulouse).

This study was supported financially by the French Health Ministry.

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Fig. 1.

Walking speed in 739 older women in relation to serum 25(OH)D concentration. The size of the circle (usual-pace walking speed: *A* and *C*) or square (fast-pace walking speed: *B* and *D*) is proportional to the number of observations. Shown are CIs for the mean. Panels *C* and *D* are adjusted for age, BMI, number of chronic diseases, quadriceps strength, regular physical activity, cognitive functioning, use of psychoactive drugs, and serum intact parathyroid hormone concentration.

Table 1

Baseline Characteristics of Subjects

	EPIDOS cohort (<i>n</i> = 6846)	Studied sample of subjects (<i>n</i> = 739)	<i>p</i> Value ^a
Age, mean ± SD years	80.5 ± 3.8	80.2 ± 3.5	.012
Number of chronic diseases, ^b mean ± SD	3.5 ± 2.0	3.0 ± 1.8	<.001
BMI, mean ± SD kg/m ²	25.4 ± 4.2	25.7 ± 4.4	.060
SPMSQ, ^c mean ± SD/10	8.4 ± 2.5	9.0 ± 1.4	<.001
Use of psychoactive drugs, ^d <i>n</i> (%)	3260 (47.6)	355 (47.2)	.830
Regular physical activity, ^e <i>n</i> (%)	3241 (47.4)	397 (52.9)	.004
Usual-pace walking speed, mean ± SD cm/s	87.7 (26.5)	86.8 (21.9)	.311
Fast-pace walking speed, mean ± SD cm/s	111.6 (35.1)	109.7 (26.5)	.065

Note: Significant *p* values (ie, *p* < .05) indicated in bold.

^aBased on independent-sample *t* test.

^bObtained from physical examination and a health status questionnaire to target comorbid conditions (eg, hypertension, diabetes, dyslipidemia, coronary heart disease, chronic obstructive pulmonary disease, peripheral vascular disease, cancer, stroke, Parkinson disease, and depression).

^cPfeiffer's Short Portable Mental State Questionnaire (/10).

^dUse of benzodiazepines, antidepressants, or neuroleptics.

^eConsidered if subjects had practiced at least one recreational physical activity (eg, walking, gymnastics, cycling, swimming, or gardening) for at least 1 hour a week for the past month or more.

Mean Values and SD of Measured Walking Speed at a Usual and Fast Pace Among Subjects Categorized in Four Groups According to Their Serum 25(OH)D Concentrations

Table 2

	Serum 25(OH)D concentration (ng/mL)				p	Trend	Overall p value ^a
	<10	10–20	20–30	>30			
Measured walking speed, mean ± SD cm/s, <i>n</i>							
Usual-pace walking speed	83.9 ± 22.6, 129	87.2 ± 21.9, 414	85.7 ± 22.0, 132	91.5 ± 20.4, 71	.068		.145
Fast-pace walking speed	105.2 ± 28.5, ^b 126	110.1 ± 26.2, 411	108.7 ± 26.5, 132	116.9 ± 25.6, 70	.007		.021

Note: Significant odds ratios (ie, *p* < .05) indicated in bold.

OR = odds ratio; CI = confidence interval

^aSeparated model for usual- and fast-pace walking tests.

Adjusted for potential confounders (ie, age, BMI, number of chronic diseases, quadriceps strength, regular physical activity, cognitive functioning, use of psychoactive drugs, and serum intact parathyroid hormone concentration).

Table 3

Uni- and Multivariate Linear Regressions Showing the Cross-Sectional Association Between Measured Walking Speeds at Usual or Fast Pace^a (Dependent Variable) and Serum 25-Hydroxyvitamin D Concentration (Independent Variable) Adjusted for Potential Confounders ($n = 739$)

	Measured walking speed			
	Usual-pace walk test		Fast-pace walk test	
	Unadjusted β (95% CI) [p value]	Adjusted β (95% CI) [p value]	Unadjusted β (95% CI) [p value]	Adjusted β (95% CI) [p value]
Serum 25(OH)D concentration (ng/mL)	0.16 (0.02 to 0.30) [.027]	0.10 (-0.03 to 0.24) [.130]	0.23 (0.06 to 0.41) [.009]	0.18 (0.01 to 0.34) [.033]
Serum iPTH concentration (pg/mL)	-0.05 (-0.10 to 0.01) [.109]	0.01 (-0.04 to 0.07) [.691]	-0.06 (-0.13 to 0.01) [.072]	0.01 (-0.06 to 0.07) [.925]
Age (years)	-1.47 (-1.92 to 1.03) [<.001]	-1.15 (-1.59 to 0.72) [<.001]	-2.02 (-2.55 to 1.48) [<.001]	-1.66 (-2.18 to 1.14) [<.001]
BMI ^b (kg/m ²)	-0.99 (-1.34 to 0.64) [<.001]	-1.31 (-1.66 to 0.96) [<.001]	-1.30 (-1.74 to 0.86) [<.001]	-1.78 (-2.20 to 1.35) [<.001]
Quadriceps strength ^c (N/m ²)	0.10 (0.06 to 0.13) [<.001]	0.09 (0.06 to 0.12) [<.001]	0.12 (0.08 to 0.16) [<.001]	0.12 (0.08 to 0.16) [<.001]
Number of chronic diseases ^d	-0.76 (-1.63 to 0.10) [.085]	0.17 (-0.68 to 1.02) [.692]	-1.25 (-2.31 to 0.19) [.021]	0.22 (-0.81 to 1.24) [.680]
Regular physical activity ^e	9.72 (6.64 to 12.79) [<.001]	4.49 (1.42 to 7.56) [.004]	12.26 (8.51 to 16.02) [<.001]	6.28 (2.58 to 9.98) [.001]
Cognitive function ^f	3.20 (2.11 to 4.29) [<.001]	3.12 (1.06 to 3.19) [<.001]	3.93 (2.56 to 5.30) [<.001]	2.72 (1.45 to 3.99) [<.001]
Use of psychoactive drugs ^g	-8.42 (-11.52 to 5.32) [<.001]	-7.01 (-9.98 to 4.04) [<.001]	-7.81 (-11.63 to 3.99) [<.001]	-5.34 (-8.92 to 1.77) [.003]

Note: Significant coefficients of regression β (ie, $p < .05$) indicated in bold.

β = coefficient of regression corresponding to an increase of walking speed expressed in centimeters per second; CI = confidence interval; 25(OH)D = 25-hydroxyvitamin D; iPTH = intact parathyroid hormone.

^aSeparated models for usual- and fast-pace walking tests.

^bNormalized by taking the logarithmic transformation.

^cNormalized by a square-root transformation.

^dAmong hypertension, diabetes, dyslipidemia, coronary heart disease, chronic obstructive pulmonary disease, peripheral vascular disease, cancer, stroke, Parkinson disease, and depression.

^eAt least 1 hour of recreational physical activity (eg, walking, gymnastics, cycling, swimming, or gardening) per week for the past month or more.

^fBased on Pfeiffer's Short Portable Mental State Questionnaire score (/10).

^gUse of benzodiazepines, antidepressants, or neuroleptics.

Table 4

Uni- and Multivariate Logistic Regressions Showing the Cross-Sectional Association Between Serum 25(OH)D Concentration Categorized in Four Levels and Being in the Worst Quintile of Walking Speed Measured at Usual or Fast Pace,^a Adjusted for Potential Confounders^b ($n = 739$)

	Usual-pace walking speed		Fast-pace walking speed	
	Unadjusted OR (95% CI) [<i>p</i> value]	Adjusted OR (95% CI) [<i>p</i> value]	Unadjusted OR (95% CI) [<i>p</i> value]	Adjusted OR (95% CI) [<i>p</i> value]
Serum 25(OH)D category				
>30 ng/mL	1	1	1	1
20–30 ng/mL	2.93 (1.07 to 8.06) [.037]	3.79 (1.21 to 11.83) [.022]	3.14 (1.24 to 7.96) [.016]	6.01 (1.86 to 19.46) [.003]
10–20 ng/mL	2.82 (1.10 to 7.26) [.031]	3.76 (1.28 to 11.00) [.016]	2.27 (0.94 to 5.43) [.067]	4.10 (1.33 to 12.58) [.014]
<10 ng/mL	5.11 (1.90 to 13.71) [.001]	5.44 (1.75 to 16.92) [.003]	4.27 (1.70 to 10.73) [.002]	6.95 (2.14 to 22.60) [.001]

Note: Significant odds ratios (ie, $p < .05$) indicated in bold.

OR = odds ratio; CI = confidence interval

^a Separated model for usual- and fast-pace walking tests.

^b Adjusted for potential confounders (ie, age, BMI, number of chronic diseases, quadriceps strength, regular physical activity, cognitive functioning, use of psychoactive drugs, and serum intact parathyroid hormone concentration).